



BS 1449: Part 1: 1983

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British Standard

Steel plate, sheet and strip

Part 1. Specification for carbon and carbon-manganese plate, sheet and strip

Tôles et feuillards en acier

Partie 1. Tôles et feuillards en aciers au carbone et aciers au carbone-manganèse — Spécifications

Bleche und Bänder aus Stahl

Teil 1. Bleche und Bänder aus Kohlenstoffstahl und Kohlenstoffmanganstahl

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Foreword

This Part of BS 1449, prepared under the direction of the Iron and Steel Standards Committee, is a complete revision of BS 1449 : Part 1 : 1972 which is withdrawn.

The revision was undertaken as a general updating operation, to bring into the standard advances in technology since the publication of the previous edition, and with particular recognition of the need to show more clearly the differences between wide and narrow mill materials. To this latter end, the requirements for narrow mill materials specified in sections four and five of the 1972 edition have been combined in section four of the present edition. In addition, the tolerances on nominal dimensions and shape included in section one of the 1972 edition are now covered separately in section five of the present edition and, again, set out clearly the differences between wide and narrow mill materials.

The general method of presentation established in the 1972 edition has been retained.

Included in this edition, for the first time, are definitions

and requirements for the various edge conditions available (see 1.2.7 and 1.18), particularly for the narrow mill materials.

The terms 'cold rolled' and 'cold reduced' have been considered as interchangeable and synonymous, as each term is used in certain sectors of industry. In this Part of the standard, only the term 'cold rolled' has been used.

In the preparation of this Part the opportunity has been taken to align the technical requirements with those of related international standards and Euronorms, so far as it has been considered to be practicable and in the best interests of British industry.

For material over 16 mm thick, reference should be made to BS 4360.

For materials specifically intended for springs, reference should be made to the Parts of BS 5770.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard

Steel plate, sheet and strip

Part 1. Specification for carbon and carbon-manganese plate, sheet and strip

Section one. General requirements

1.0 Introduction

1.0.1 Designation system. In this revision, symbols have been used to indicate all the conditions and surface finishes in which the various materials are available. The meaning of these symbols is given in tables 1 and 2 and their use is described below and in 2.5, 3.5 and 4.5. Each of these clauses also includes a table which indicates the combinations of conditions and surface finishes which are available for a particular grade of material.

Attention is drawn to the fact that it is not obligatory for the purchaser of a fabricated component to specify the manufacturing method for the flat rolled material. However, when it is necessary to specify the manufacturing method, the symbols concerned with material conditions (see table 1) precede the material grade number in the following manner:

- (a) The symbols R, B or K signifying either a rimmed, balanced or killed steel.
- (b) The symbols HR, HS, CR or CS signifying the type of rolling.
- (c) The symbol SP when the material is required in the skin passed condition.
- (d) Any other symbol concerned with material condition and which is appropriate to the grade being ordered (see the tables on availability in the appropriate sections of the standard).

Any symbols concerned with surface finish (see table 2) appear after the material grade number.

Thus, material K CRSP 34/20 GP designates a killed steel in the form of cold rolled, skin passed, grade 34/20 wide strip, supplied with a general purpose finish.

Material 34/20 GP would be used to specify this material when the purchaser did not wish to be more precise about the manufacturing method.

NOTE. When it is required to specify an edge condition (see 1.2.7 and 1.18) it is sufficient to add, after the designation of the material, the symbol indicating the edge condition, e.g. 'edge E1'.

1.0.2 Summary of material grades, chemical compositions and types of steel available. The material grades, chemical compositions and types of steel available in sections two, three and four of this standard are summarized in table 3.

1.1 Scope

This Part of this British Standard specifies requirements for flat rolled carbon steel products, available in the hot or cold rolled conditions and in coil or cut length form, rolled as wide strip in nominal widths of 600 mm and wider, or as narrow strip in nominal widths less than 600 mm.

It covers plate, sheet and strip in nominal thicknesses up to and including 16 mm and of the material grades, chemical compositions and types of steel summarized in table 3.

The contents of each section of this standard are as follows.

Section one gives definitions of the products specified, general requirements and information applicable to all products.

Section two specifies requirements for low carbon steel (0.20 % max.) plate, sheet and strip intended for applications where formability is a major requirement.

Section three specifies requirements for carbon-manganese and micro-alloyed steel plate, sheet and strip intended for use where the essential requirement is a specified minimum strength.

Section four specifies requirements for low, medium and high carbon steels, rolled in nominal widths less than 600 mm, available in a range of conditions for heat treatment and general engineering purposes.

Section five specifies requirements for tolerances on dimensions and permissible deviations in shape.

Appendix A provides a correlation of this Part of the standard to BS 4360 by giving nearest equivalents for steels in BS 4360, based on yield stress only.

Stress unit conversions are given in appendix C.

NOTE. The titles of the publications referred to in this Part of BS 1449 are listed on the inside back cover.

1.2 Definitions

For the purposes of this British Standard the following definitions apply.

1.2.1 flat products. Products of almost rectangular cross section with a width much greater than the thickness.

1.2.2 hot rolled flat products. Flat products produced by hot rolling.

NOTE. The very light cold rolling pass called 'skin pass' or 'dressing pass', generally resulting in a reduction in thickness of less than 5 %, that is given to certain hot rolled flat products does not alter their classification as hot rolled products.

Table 1. Symbols for material conditions (see note)

Condition	Symbol	Description
Rimmed steel	R	Low carbon steel in which deoxidation has been controlled to produce an ingot having a rim or skin almost free from carbon and impurities, within which is a core where the impurities are concentrated
Balanced steel	B	A steel in which processing has been controlled to produce an ingot with a structure between that of a rimmed and a killed steel. It is sometimes referred to as semi-killed steel
Killed steel	K	Steel that has been fully deoxidized
Hot rolled on wide mills	HR	Material produced by hot rolling. This will have an oxide scale coating, unless an alternative finish is specified (see table 2)
Hot rolled on narrow mills	HS	
Cold rolled on wide mills	CR	Material produced by cold rolling to the final thickness
Cold rolled on narrow mills	CS	
Normalized	N	Material that has been normalized as a separate operation
Annealed	A	Material in the annealed last condition (i.e. which has not been subjected to a final light cold rolling)
Skin passed	SP	Material that has been subjected to a final light cold rolling
Temper rolled	H1 H2 H3 H4 H5 H6	Material rolled to the specified temper and qualified as follows: H1 = eighth hard H2 = quarter hard H3 = half hard H4 = three-quarters hard H5 = hard H6 = extra hard
Hardened and tempered	HT	Material that has been continuously hardened and tempered in order to give the specified mechanical properties

NOTE. For availability see note 2 to 2.5.1, note 2 to 3.5.1 and note 1 to 4.5.1.

1.2.3 cold rolled flat products. Flat products that have undergone a reduction in thickness of at least 25 % by cold rolling.

NOTE. In the case of flat products of nominal width less than 600 mm, and for certain qualities of steel, material with a reduction of less than 25 % may be included in this category.

1.2.4 hot or cold rolled strip. A hot or cold rolled flat product which immediately after the final rolling pass is wound into regularly superimposed laps so as to form a coil with almost flat sides.

NOTE. Strip as rolled normally has slightly convex edges (mill edges), but it may also be supplied with sheared or other edges (see 1.2.7) or may be obtained by slitting from wider strip. Strip may be subsequently cut and supplied as sheet or cut lengths, or as coils of any narrower width.

According to its rolled nominal width, strip is classified as defined in 1.2.4.1 and 1.2.4.2.

1.2.4.1 hot or cold rolled narrow strip. Strip rolled in nominal widths less than 600 mm.

NOTE. After decoiling and cutting to length, narrow strip may be supplied as cut lengths or in folded bundles. Thicknesses over 3 mm may be rolled in flat lengths.

1.2.4.2 hot or cold rolled wide strip. Strip rolled in nominal widths equal to or greater than 600 mm.

1.2.5 hot or cold rolled sheet or plate. A flat rolled product cut from hot rolled or cold rolled strip, rolled on a continuous mill with the edges being allowed to deform freely during rolling, supplied flat and generally square or rectangular, the edges as rolled or sheared.

According to thickness, sheet or plate is traditionally classified as:

- (a) sheet: nominal thickness less than 3 mm;
- (b) plate: nominal thickness equal to or greater than 3 mm and, for the purpose of this Part of BS 1449, up to and including 16 mm.

1.2.6 slit wide strip. Strip that has been slit from wide strip.
NOTE. It may have a nominal width less than 600 mm.

1.2.7 Edge conditions (see also 1.18)

1.2.7.1 mill edge (E1). The natural edge produced when strip is rolled.

Table 2. Symbols for surface finishes and surface inspection

Finish	Symbol	Description
Pickled	P	A hot rolled surface* from which the oxide has been removed by chemical means
Mechanically descaled	D	A hot rolled surface* from which the oxide has been removed by mechanical means
Full finish	FF	A cold rolled skin passed material having one surface free from blemishes liable to impair the appearance of a high class paint finish (see note 3)
General purpose finish	GP	A cold rolled material free from gross defects, but of a lower standard than FF (see note 3)
Matt finish	M	A surface finish obtained when material is cold rolled on specially prepared rolls as a last operation
Bright finish	BR	A surface finish obtained when material is cold rolled on rolls having a moderately high finish. It is suitable for most requirements, but is not recommended for decorative electroplating.
Plating finish	PL	A surface finish obtained when material is cold rolled on specially prepared rolls to give one surface which is superior to a BR finish and is particularly suitable for decorative electroplating
Mirror finish	MF	A surface finish having a high lustre and reflectivity. Usually available only in narrow widths in cold rolled material
Unpolished finish	UP	A blue/black oxide finish; applicable to hardened and tempered strip
Polished finish	PF	A bright finish having the appearance of a surface obtained by fine grinding or abrasive brushing; applicable to hardened and tempered strip
Polished and coloured blue	PB	A polished finish oxidized to a controlled blue colour by further heat treatment; applicable to hardened and tempered strip
Polished and coloured yellow	PY	A polished finish oxidized to a controlled yellow colour by further heat treatment; applicable to hardened and tempered strip
Vitreous enamel	VE	A surface finish for vitreous enamelling of material of specially selected chemical composition
Special finish	SF	Other finishes by agreement between the manufacturer and the purchaser

*A hot rolled surface supplied in the as-rolled condition, i.e., a non-descaled surface; some surface defects of steelmaking or rolling origin may be present, the proportion being greater with strip than with sheet or plate.

NOTE 1. Some of these finishes are available only from wide mills, others only from narrow mills. For availability see note 3 to 2.5.1, note 2 to 3.5.1 and note 2 to 4.5.1.

NOTE 2. By special agreement between the supplier and the purchaser, cold rolled material can be supplied to surface texture specifications. The information to be given in statements about surface texture requirements is specified in BS 1134 : Part 1.

NOTE 3. GP and FF finishes are normally supplied with a matt appearance.

Table 3. Summary of material grades, chemical compositions and types of steel available

Section no.	Material grade	Rolled condition (see table 1)	Chemical composition								Types of steel
			C		Si		Mn		S	P	
			min.	max.	min.	max.	min.	max.	max.	max.	
2	Materials having specific requirements based on formability (see also 2.3)										
	1	HR, HS, —, —	%	%	%	%	%	%	%	%	Extra deep drawing aluminium-killed steel Extra deep drawing aluminium-killed stabilized steel Extra deep drawing Deep drawing Drawing or forming Flanging Commercial
	1	—, —, CR, CS	—	0.08	—	—	—	0.45	0.030	0.025	
	2	HR, HS, CR, CS	—	0.08	—	—	—	0.45	0.035	0.030	
	3	HR, HS, CR, CS	—	0.10	—	—	—	0.50	0.040	0.040	
	4	HR, HS, CR, CS	—	0.12	—	—	—	0.60	0.050	0.050	
	14	HR, HS, —, —	—	0.15	—	—	—	0.60	0.050	0.050	
	15	HR, HS, —, —	—	0.20	—	—	—	0.90	0.050	0.060	
3	Materials having specific requirements based on minimum strengths (see also 3.3)										
	<i>Carbon-manganese steels</i>										
	34/20	HR, HS, CR, CS	—	0.15	—	—	—	1.20	0.050	0.050	Available as rimmed (R), balanced (B) or killed (K) steels. Grain-refined balanced (B) or killed (K) steel.
	37/23	HR, HS, CR, CS	—	0.20	—	—	—	1.20	0.050	0.050	
	43/25	HR, HS, —, —	—	0.25	—	—	—	1.20	0.050	0.050	
	50/35	HR, HS, —, —	—	0.20	—	—	—	1.50	0.050	0.050	
	<i>Micro-alloyed steels</i>										
	40/30	HR, HS, —, CS	—	0.15	—	—	—	1.20	0.040	0.040	Grain-refined niobium- or titanium-treated fully killed steels having high yield strength and good formability
	43/35	HR, HS, —, CS	—	0.15	—	—	—	1.20	0.040	0.040	
	46/40	HR, HS, —, CS	—	0.15	—	—	—	1.20	0.040	0.040	
	50/45	HR, HS, —, CS	—	0.20	—	—	—	1.50	0.040	0.040	
	60/55	—, HS, —, CS	—	0.20	—	—	—	1.50	0.040	0.040	
	40F30	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	The steels including F in their designations in place of the oblique line offer superior formability for the same strength levels
	43F35	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	46F40	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	50F45	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	60F55	—, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	68F62	—, HS, —, —	—	0.12	—	—	—	1.50	0.035	0.030	
	75F70	—, HS, —, —	—	0.12	—	—	—	1.50	0.035	0.030	
4	Narrow strip supplied in a range of conditions for heat treatment and general engineering purposes (see also 4.3)										
	4	—, HS, —, CS	—	0.12	—	—	—	0.60	0.050	0.050	Low carbon steel available hot rolled, annealed, skin passed or cold rolled to controlled hardness ranges H1 to H6 inclusive
	10	—, HS, —, CS	0.08	0.15	0.10	0.35	0.60	0.90	0.045	0.045	For case hardening
	12	—, HS, —, CS	0.10	0.15	—	—	0.40	0.60	0.050	0.050	A range of carbon steels available in the hot rolled or annealed condition.
	17	—, HS, —, CS	0.15	0.20	—	—	0.40	0.60	0.050	0.050	
	20	—, HS, —, CS	0.15	0.25	0.05	0.35	1.30	1.70	0.045	0.045	
	22	—, HS, —, CS	0.20	0.25	—	—	0.40	0.60	0.050	0.050	
	30	—, HS, —, CS	0.25	0.35	0.05	0.35	0.50	0.90	0.045	0.045	A range of carbon steels for use in the hot rolled, normalized, annealed and (except for grade 95) in the temper rolled (half hard) conditions. Grades 40 and 50 may be induction or flame hardened and grades 60, 70, 80 and 95 may be supplied in the hardened and tempered condition
	40	—, HS, —, CS	0.35	0.45	0.05	0.35	0.50	0.90	0.045	0.045	
	50	—, HS, —, CS	0.45	0.55	0.05	0.35	0.50	0.90	0.045	0.045	
	60	—, HS, —, CS	0.55	0.65	0.05	0.35	0.50	0.90	0.045	0.045	
	70	—, HS, —, CS	0.65	0.75	0.05	0.35	0.50	0.90	0.045	0.045	
	80	—, HS, —, CS	0.75	0.85	0.05	0.35	0.50	0.90	0.045	0.045	
	95	—, HS, —, CS	0.90	1.00	0.05	0.35	0.30	0.60	0.040	0.040	

1.2.7.2 sheared edge or slit edge (E2). The edge of strip that has been cut to size by guillotine or rotary cutters. The burr is not eliminated.

1.2.7.3 dressed edge (E3). The edge obtained when the sheared, slit or mill edge has been removed to produce a regular form, usually square or round.

1.2.7.4 rolled round edge (E4). A rounded edge produced by edge rolling either the natural edge of rolled strip or sheared or slit edge strip. This edge is produced when an approximately round edge is desired and when the finish of the edge is not important.

1.2.7.5 sheared or slit and de-burred edge (E5). An approximately square edge produced by rolling or filing sheared or slit strip, for the purpose of removing the shearing or slitting burr only.

1.2.7.6 rolled square edge (E6). The edge produced by edge rolling to give an approximately square edge.

1.3 General

The material shall comply with the general requirements of section one, with the appropriate specific requirements of section two, three or four and the appropriate tolerances on dimensions and permissible deviations in shape in section five.

NOTE. Particular attention is drawn to the fact that material produced on narrow mills (which has the letters 'HS' or 'CS' included in the designation) will always have different dimensional tolerances and sometimes different mechanical properties from material produced on wide mills (which has the letters 'HR' or 'CR' included in the designation). References are made to the differences in appropriate places in the standard but some grades are only available as narrow mill products (see section four).

1.4 Steelmaking process

Unless otherwise required and stated on the order, the steel may be made by any process except that the air, and mixed air-oxygen, bottom-blown basic converter processes shall not be used.

1.5 Chemical composition

1.5.1 Cast analysis. The chemical composition of the steel shall be determined by cast analysis and shall comply with the appropriate requirements of sections two, three or four.

If specified on the order, the supplier shall state on a test certificate the cast analysis of the material supplied. Any subsequent analytical checks shall take into consideration the heterogeneity normal to the steel (see 1.5.2), and shall not be used as a basis for rejection unless the supply of an incorrect grade is clearly indicated.

1.5.2 Product check analysis. For materials from sections three and four, where killed steels are required, the permitted variations on product analysis shall be in accordance with appendix B.

Samples for product analysis shall be taken in accordance with the requirements of BS 1837 and, in the event of dispute, analysed in accordance with the appropriate method of British Standards Handbook No. 19.

NOTE to 1.5.

Residual elements. For special applications the purchaser, by agreement with the supplier, may set a limit to the amount of one or more residual elements and/or may require the amount of such elements to be stated on the certificate of analysis.

1.6 Freedom from defects

The steel shall be free from amounts of segregation, laminations, surface flaws and other defects which are detrimental to appropriate processing and, where specified, the end use.

NOTE. Where coil is supplied, the degree or amount of surface defects may be expected to be more than in cut lengths because of the impossibility of rejecting portions of a coil. This should be taken into account by the purchaser in his assessment of the material.

1.7 Condition of material on delivery

The condition of material on delivery shall be in accordance with the appropriate requirements specified in 2.5, 3.5 and 4.5. Unless otherwise stated on the enquiry and order (see 2.2.1(l), 3.2.1(j) and 4.2.1(m)), all materials other than hot rolled shall be supplied with an oil or other protective coating.

NOTE. By agreement between manufacturer and purchaser a particular protective coating may be available.

1.8 Number of tests

The manufacturer shall carry out sufficient tests in accordance with the relevant clauses of this standard in order to ensure that the material complies with the requirements of this specification.

For wide mill products and narrow mill hot-rolled products, when a test certificate is required (see 2.2.1(j), 3.2.1(h) and 4.2.1(j)) a minimum of one test of each type specified by the purchaser or required by the relevant material specification in this standard shall be taken for each 30 tonnes or parts thereof for each item.

For products cold rolled on narrow mills, the test unit shall be 5 tonnes.

NOTE. A coil greater than 5 tonnes in mass may be regarded as one test unit.

For the purposes of this standard, a test unit shall consist of one grade and finish, of a given nominal width and thickness, from one cast, processed as a single batch.

1.9 Tensile test

1.9.1 Selection of test samples. Tensile test samples shall, where possible, be taken from a position at least 20 mm from the edge of the material. They shall be taken parallel to, or at 90° to, the direction of rolling, except in the case of material rolled on narrow mills, when they shall be taken parallel to the direction of rolling.

1.9.2 Test pieces. The appropriate test pieces shall be in accordance with the requirements of BS 18 : Part 2 or Part 3.

1.9.3 Test method. The tensile strength, yield strength and elongation, as appropriate, shall be determined in accordance with BS 18 : Part 2 or Part 3.

For the purposes of this British Standard, the yield strength (R_e) shall be either the lower yield stress (R_{eL}) or the 0.5 % total elongation proof stress ($R_{t0.5}$).

If a test piece breaks outside the middle third of the gauge length, the result may, at the option of the supplier, be discarded and another test made from the same material. In acceptance testing, however, the test results may be regarded as valid, irrespective of the fracture position in the gauge length, if the minimum specified values are obtained.

1.10 Bend test (see also 2.4, 3.4, 4.4 and notes on manipulation in sections two and three).

1.10.1 Selection of test samples. Bend test samples shall, where possible, be taken from a position at least 20 mm from the edge of the material. They shall be cut so that the axis of the bend is parallel to the direction of final rolling (see figure 1). In the case of material too narrow to permit this, the axis of the bend shall be at 90° to the direction of rolling (see figure 2).

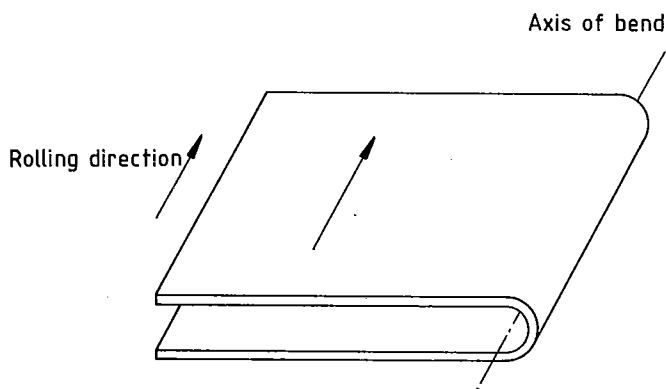


Figure 1. Bend test with the axis of the bend parallel to the direction of rolling

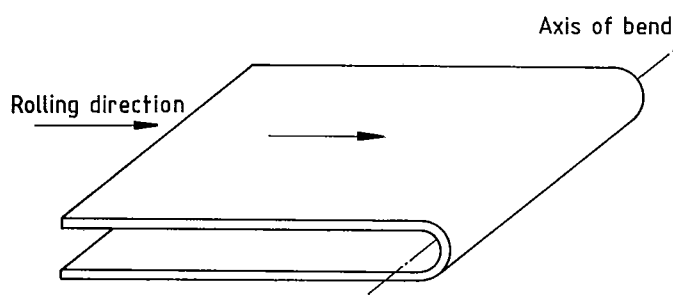


Figure 2. Bend test with the axis of the bend at 90° to the direction of rolling

1.10.2 Test pieces. If the material dimensions permit, a rectangular test piece not less than 75 mm long by 25 mm wide shall be used for thicknesses less than 3 mm, and not less than 40 mm wide for thicknesses of 3 mm and over. For smaller sizes, the maximum width obtainable shall be used.

The test pieces shall have edges that are rounded or smoothed longitudinally to an approximately semi-circular contour.

1.10.3 Test method. The bend test shall be carried out in accordance with BS 1639. The bend test pieces shall be bent cold through the angle and to the mandrel diameter (both specified for the grade in the appropriate section of this standard) by pressure or hammer blows, optionally over a former.

The test piece shall be deemed to pass the test if the outer convex surface is free from cracks. Occasionally it is difficult to ensure that the material is accurately following the specified diameter and, in cases of dispute, a test piece shall be pushed into a block of soft material by a former in accordance with Method 3 of BS 1639.

1.11 Strain-age-embrittlement test (see also 2.5.4 and 3.5.3)

1.11.1 Selection of test samples. Where possible, test samples shall be taken from a position at least 20 mm from the edge of the material and shall be cut so that the axis of the bend is parallel to the direction of final rolling (see figure 1). In the case of material too narrow to permit this, the axis of bend shall be at 90° to the direction of rolling (see figure 2).

1.11.2 Test pieces. If the material dimensions permit, a rectangular test piece of not less than 75 mm long by 25 mm wide shall be used for nominal thicknesses less than 3 mm, and not less than 40 mm wide for nominal thicknesses of 3 mm and over. For smaller sizes, the maximum width obtainable shall be used.

The test pieces shall have edges that are rounded or smoothed longitudinally to an approximately semi-circular contour.

1.11.3 Test method. The test piece shall be bent cold through 90° over a diameter equal to three times its thickness. Bending shall be about an axis at right angles to the length of the test piece.

The test piece shall then be heated within the range 320 °C to 350 °C for 15 min and cooled to room temperature in still air.

The test piece shall then be straightened by hammer blows on the apex of the bend and shall flatten without breaking.

1.12 Test for stabilization

The test for stabilization shall apply to skin passed stabilized steels only (see paragraph 5 of note to 2.5).

A tensile test piece shall be subjected to a total strain of 10 % and the load (P_1) required to produce this strain shall be noted. The test piece shall then be subjected to an accelerated ageing treatment by heating at a nominal temperature of 100 °C for 30 min. The test piece shall thereafter again be strained to 10 %, calculated on the original (unstrained) gauge length, and the load (P_2) noted.

The steel shall be considered stabilized if the percentage increase in load:

$$\frac{P_2 - P_1}{P_1} \times 100$$

does not exceed 6 %.

NOTE. A 6 % increase in load corresponds to a strain-ageing index of 6.

1.13 Formability tests

NOTE 1. Formability is normally assessed by means of the elongation, as determined in the tensile test specified in 1.9, and the modified Erichsen cupping test, as specified in 1.13.1.

NOTE 2. Tests for formability vary widely and involve two major components: stretch and draw.

The stretching properties are assessed by measurements such as elongation and Erichsen cupping test values.

Drawability requires separate consideration and the determination of 'r' values, or simulative cup-draw tests, are appropriate for this purpose. In the absence of British Standards covering these tests, the test method given in appendix D may be used to determine 'r' values.

NOTE 3. Aluminium-stabilized grades CR/CS 1 are superior to steel grades CR/CS 2 to 4 for drawing applications.

1.13.1 Modified Erichsen cupping test (see figure 3).

The modified Erichsen cupping test shall be carried out in accordance with BS 3855 and shall apply only to the formability grades, included in section two, having a nominal thickness of up to and including 2 mm.

The surface of the cup shall be smooth and the fracture shall not exhibit any undue directionality. The lubricant for the test shall be graphited grease or polyethylene sheet in accordance with BS 3855. In cases of dispute the reference method shall employ polyethylene sheet as a lubricant.

1.14 Hardness test

For narrow strip, unless otherwise agreed, the method for testing shall be the Vickers hardness test, which shall be carried out on the surface of the material, in accordance with BS 427 : Part 1.

NOTE 1. Attention is drawn to the recommendations for the minimum thicknesses for test pieces, given in appendix C of BS 427 : Part 1 : 1961.

NOTE 2. Vickers hardness values (HV) are specified for certain of the steels included in section four.

Where a preference is stated for either Rockwell or Brinell hardness tests, the appropriate value shall be agreed at the time of ordering. Such tests shall be carried out in accordance with either BS 891 : Part 1 or BS 240 : Part 1 respectively.

NOTE 3. The Rockwell hardness test is the normal method of testing for wide strip.

NOTE 4. There are several methods for testing the hardness of flat rolled steel, but as there is no general procedure for accurately converting one scale of hardness to another, it is recommended that such conversions should be avoided.

1.15 Decarburization test

In cases of dispute, the extent of decarburization shall be determined by examination of a carefully prepared cross section of a copper-plated and normalized sample of the steel strip at a magnification of $\times 200$ diameters.

NOTE 1. A British Standard method for determination of the extent of decarburization is in course of preparation.

NOTE 2. Care should be taken to avoid additional decarburization during normalizing.

1.16 Retests

If a test fails to meet the requirements of this standard, the manufacturer may take two additional tests from the material represented, one of which shall be from the original bundle or coil. If either of these additional tests fails to meet the specified requirements, the material shall be deemed not to comply with the standard.

The supplier shall have the right to reprocess and resubmit the material for inspection and testing.

1.17 Surface finish and surface inspection

The material shall be supplied in the as-rolled finish or, subject to availability as indicated in 2.5, 3.5 and 4.5 and if stated on the order, one of the finishes given in table 2. Only one surface shall be inspected to the appropriate requirements and that surface shall be marked with the manufacturer's brand (see 1.21) unless otherwise agreed between the manufacturer and the purchaser.

NOTE. By agreement between the manufacturer and the purchaser, other finishes to those specified may be available.

1.18 Edge conditions

NOTE. The availability of the edge conditions is indicated in table 4.

The following requirements shall apply to the edge condition specified:

(a) *Mill edges* (E1). The edges of narrow strip shall be free from defects greater than 1.5 mm depth normal to the edge.

NOTE 1. By agreement between the manufacturer and the purchaser, more stringent requirements to those specified may be available.

NOTE 2. The requirements applicable to edges of wide strip should be by agreement between the manufacturer and purchaser.

(b) *Sheared edges or slit edges* (E2). It is permissible for edges to exhibit transverse cutting marks, but they shall show no evidence of chipped cutting tools or edge cracks.

(c) *Dressed edges* (E3). The process used to dress the edges shall not be detrimental to the metallurgical structure of the strip. The strip shall not show edge defects.

(d) *Rolled round edges* (E4). The edges shall be free from defects greater than 1.5 mm depth normal to the edge.

(e) *Sheared or slit and de-burred edges* (E5). It is permissible for edges to exhibit transverse cutting marks, but they shall show no evidence of chipped cutting tools, or edge cracks, burr or turn-down.

(f) *Rolled square edges* (E6). The edges shall be free from defects greater than 1.5 mm depth normal to the edge.

1.19 Inspection

The purchaser or his representative shall have reasonable access to the works of the manufacturer for the purpose of inspection. If such inspection is to be carried out, this shall be stated when placing the order.

NOTE. In continuous mill practice, all orders are subject to a detailed internal system of inspection and testing. Because the period between inspection, or testing, and despatch may be only a few hours, it is desirable that, whenever possible, the external inspection should use the records available.

1.20 Tolerances on dimensions and shape

The tolerances on dimensions and shape shall be in accordance with section five.

NOTE. By agreement between purchaser and manufacturer other tolerances may be available.

1.21 Marking

Material shall be identified. Material which is too small for individual marking shall be bundled and identified by a tag or label. No supplier's brand marks (see 1.17), applied to the material, shall interfere with subsequent normal processing. In the case of sheet and strip, the material shall be identified either by individual marking or by a label.

Table 4. Edge conditions

Material	Edge condition (see 1.2.7)					
	Mill edge	Sheared or slit edge	Dressed edge	Rolled round edge	Sheared or slit and deburred edge	Rolled square edge
	(E1)	(E2)	(E3)	(E4)	(E5)	(E6)
Wide mill	X	X	—	—	—	—
Narrow mill	X	X	X	X	X	X

X indicates availability of edge condition.

NOTE. Edge conditions E1 to E6 may not be available in all combinations of nominal width and thickness.

Section two. Specific requirements for materials based on formability

2.1 General

Low carbon (0.20 % max.) steel plate, sheet and strip, intended for applications where formability is a major requirement, shall comply with the requirements of this section.

NOTE 1. Particular attention is drawn to the fact that although the grades specified in this section are produced on both narrow and wide mills, the tolerances of narrow mill products (which include 'HS' or 'CS' in their designations) will always be different from those from wide mills. The fabricator should refer to the appropriate tables to determine which will be the most suitable material for him to use in relation to the type of component that is being formed.

NOTE 2. The combination of conditions and surface finishes, related to wide and narrow mill products, for this type of material are given in note 4 to 2.5.1 and table 9.

2.2 Information to be supplied by the purchaser

2.2.1 General. The following information shall be given on the enquiry and order. Purchasers should pay particular attention to the various options available in this standard and included in the list below. Where no specific choice is made by the purchaser, the supplier shall select what is appropriate, except that for items (a), (b), (c) and (d) reference back to the purchaser shall be made:

- (a) the number of this Part of this British Standard, i.e. BS 1449 : Part 1;
- (b) the form of product required, i.e. plate, sheet or strip (see 1.2);
- (c) the nominal dimensions (see section five) and quantity of the product required;
- (d) the condition, grade and surface finish of the material (see 2.2.4, 2.5.1 and 2.5.2);
- (e) if the material is to be supplied as 'SUITABLE FOR MAKING THE PART' (see 2.2.2 and 2.2.3);
- (f) the edge condition required (see 1.18);
- (g) the application for which the material is intended, including the submission of a drawing;
- (h) whether proof of freedom from strain-age-embrittlement for grades 2, 3 or 4 (see 2.5.4) is required;
- (i) if the material is to be welded the welding method to be used (see 2.5.3);

(j) whether test certificates are required for cast analysis (see 1.5.1) and/or mechanical properties (see 1.8 and 2.4);

(k) whether the purchaser wishes to carry out inspection at the manufacturer's works (see 1.19);

(l) whether oiling or other protective coating is *not* required (see 1.7);

(m) any limitations on masses and dimensions of individual coils or bundles if applicable;

(n) details of any special requirements, e.g. agreed tests for drawability (see 1.13);

(o) whether special requirements are necessary for packaging or marking (see 1.21).

2.2.2 Suitability for making the part

NOTE. Formability requirements vary widely and it is advisable with the steels in this section to seek the advice of the supplier and, if possible, to purchase material on the understanding that it will be suitable for a particular application and/or purpose.

Subclause 2.2.1(e) is to cover such a case.

When, following an enquiry, the supplier undertakes to supply steel which is suitable for forming into a particular part, the purchaser, when ordering the steel, shall add the words 'SUITABLE FOR MAKING THE PART' after the grade selected.

In such cases, the steel supplied shall not be subject to rejection if there are minor variations from the chemical composition and/or mechanical properties specified for that steel.

2.2.3 Grade specified by purchaser. Where a purchaser specifies a particular grade and 2.2.2 is not invoked, then it shall be the purchaser's responsibility that the grade will be satisfactory for his requirements.

2.2.4 Grade and condition by consultation. Where a purchaser is unqualified to select a particular material in terms of grade and condition, it shall be sufficient for him to specify the requirements in 2.2.1(a), (b) and (c). It shall then be the responsibility of the supplier, in consultation with the purchaser, to select and supply a grade and condition of material which will be satisfactory for the purchaser's requirements. The purchaser shall select a particular surface finish of material in accordance with note 3 to 2.5.1 if so required, e.g. BS 1449 : Part 1. PL.

2.3 Chemical composition (see also 1.5.1)

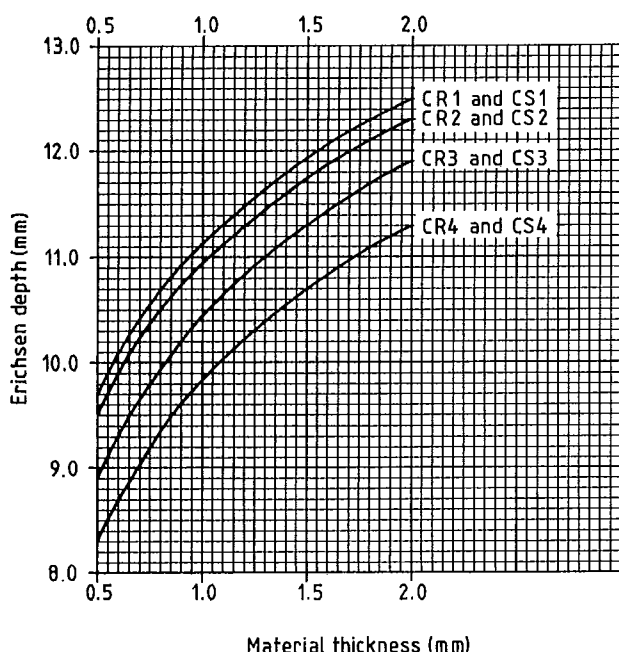
The chemical composition of the materials shall be as shown in table 5.

Materials CR1, HR1, CS1 and HS1 shall be aluminium-killed steels. Unless otherwise agreed at the time of ordering, the deoxidation condition of all other grades shall be at the discretion of the manufacturer.

2.4 Mechanical properties

The mechanical properties of the materials at the time of despatch shall be as given in tables 6, 7 and 8; the Erichsen cupping test values (see 1.13) shall be as given in figure 3.

NOTE. All the steels included in tables 6 to 8, other than stabilized grades, may strain-age harden (see note to 2.5) and the ductility will therefore deteriorate.



NOTE. In the case of material in the CS condition, the modified Erichsen cupping test values are for guidance only and are not mandatory except by special agreement between the manufacturer and the purchaser.

Figure 3. Minimum Erichsen cupping test values (using polyethylene sheet as lubricant) for materials based on formability (see 1.13.1)

2.5 Condition of material on delivery

2.5.1 Designation (see also 1.0.1). The condition and finish of the material shall be in accordance with the symbols included with the material grade, and given on the enquiry and order (see 2.2).

The symbols, if required, denoting material condition (see table 1) shall be given before the grade number of the steel, in the following order:

- the symbol R, B or K signifying the type of steel;
- the symbols HR, HS, CR or CS signifying the method of rolling;
- the symbols SP or A if the material is required in the skin passed or annealed condition respectively.

NOTE 1. Attention is drawn to the fact that it is not obligatory for the purchaser of a fabricated component to specify the manufacturing method for the flat rolled material.

Symbols denoting surface finish (see table 2) shall appear after the grade number of the steel.

Example. CSSP 3 PL signifies cold rolled skin passed grade 3 narrow strip, supplied with a finish suitable for electroplating.

NOTE 2. **Material conditions.** The following material conditions are available; more complete descriptions are given in table 1:

- HR Hot rolled on wide mills
- HS Hot rolled on narrow mills
- CR Cold rolled on wide mills
- CS Cold rolled on narrow mills
- SP Skin passed
- A Annealed

NOTE 3. **Surface finishes (see also 1.17).** The following are available; more complete descriptions are given in table 2:

Material rolled on wide mills (HR, CR)

- P Pickled
- GP General purpose
- FF Full finish
- BR Bright finish
- PL Plating finish
- VE Vitreous enamel

Material rolled on narrow mills (HS, CS)

- P Pickled
- D Mechanically descaled
- M Matt finish
- BR Bright finish
- PL Plating finish
- MF Mirror finish
- VE Vitreous enamel
- SF Special finish

NOTE 4. **Condition and surface finish combinations.** The combinations of material conditions and surface finishes that are available in addition to the 'as-rolled' condition are indicated in table 9. There may be some limitation on the thicknesses and widths available.

2.5.2 Cold rolled wide strip. Cold rolled wide strip is normally supplied in the skin passed (SP) condition; if required in the annealed (A) condition this shall be stated on the enquiry and order (see 2.2.1(d)).

NOTE. In special circumstances it is permissible for a very light skin pass to be applied to annealed material by agreement between the manufacturer and the purchaser.

2.5.3 Weldability (see also 2.2.1(i)). All grades shall be weldable by suitable resistance welding techniques.

NOTE. Extra precautions should be exercised in the spot welding of grades 14 and 15.

If fusion welding techniques are to be used, this shall be stated on the order.

2.5.4 Strain-age-embrittlement. Grade 1 shall be free from strain-age-embrittlement (see 1.11). Freedom from strain-age-embrittlement for other grades shall be by agreement between the manufacturer and the purchaser (see 2.2.1(h)).

NOTE TO 2.5.

Strain-ageing. Rimmed steel, as normally produced, strain-ages when supplied in the skin passed condition and this may lead to:

- increase in hardness;
- stretcher strain markings (Lüder's lines) when the material is formed;
- deterioration in ductility.

Because of these factors, it is essential that the period between final processing at the mill and fabrication be kept to the minimum.

Rotation of stock by using the oldest material first is important. Stocking of these skin passed steels for extended periods of time should be avoided and, for optimum performance, should not exceed six weeks.